§4. Fusion Neutron Effects on CCD Image Sensors

Iida, T.(Osaka Univ.), Sakabe, S.(Osaka Univ.), Tanimura, Y.(Osaka Univ.), Sato, F.(Osaka Univ.) and Sasao, M.

Irradiation experiments with intense radiation sources have been conducted for damage studies on a variety of materials and components necessary for a fusion reactor. In order to examine radiation effects on CCD image sensors, interline type samples (ICX054, pixel size ; 9.4 μm x 7.3 μm, pixel number ; 510 x 492) were irradiated with ^{60}Co γ-rays and fusion neutrons. The sample was set in a dark box near a radiation source and video signals from the sample were in-situ recorded with a video recorder during irradiation. The recorded video signals were analysed with an image processing system after irradiation.

The transient effect based on the radiation reaction (or detection) in the CCD sensor was observed as the generation of brightening spot noises during neutron and γ-ray irradiations. The brightening spots are assemblies of pixels influenced by electric charge generated due to radiation reactions like the incidence of light. The production rate of the brightening spot noises naturally increased in proportion to the neutron and γ-ray fluxes. The sensitivity of the CCD image sensor for DT and DD neutrons and γ -rays is summarized in Table 1.

As the permanent effect, the number of damaged pixels and the leakage current of pixels increased with neutron and γ-ray fluences. Figure 1 shows the distributions of the damaged pixels in the CCD sensor after neutron and γ-ray irradiations. It is clear from the figure that the pixels of the CCD have suffered larger damage for fusion neutrons than for γ-rays. Under the same neutron fluence, the number of the damaged pixels induced by DT neutron irradiation was slightly larger than that by DD neutron irradiation. Regarding the total leakage current of damaged pixels, the damage coefficient for DT neutrons was about 2 times larger than that for DD neutrons. This factor 2 approximately agreed with results of the displacement damage calculations on silicon, which have been described in our previous paper[1-3].

Table 1. Production rate of brightening spots on ICX054 CCD image sensor for gamma-rays and neutrons.

Radiation Type	Production rate of brightening spot (1/cm^2)
^{60}Co gamma-ray	2.5×10^{-4}
DT neutron	2.1×10^{-4}
DD neutron	3.1×10^{-5}

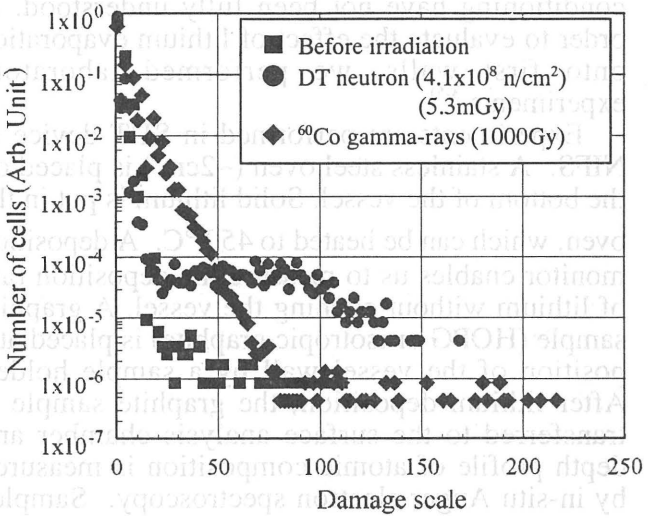

Fig.1 Radiation damge on CCD image sensor (ICX054).

References

[1] Iida, T. et al., J. Nucl. Sci. Technol., 26[2], 231 (1989)

[2] Iida, T. et al., Proc. 8th Workshop on Radiation Detectors and Their Uses, KEK, pp.158-163 (1994).

[3] Tanimuta, Y. and Iida, T., J. Nucl. Mater., (in press) (1998).